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METHOD AND EQUIPMENT FOR POSITIONING WHEN REPLACING ANODES IN
AN ELECTROLYSIS CELL ~~method and equipment for positioning when replacing
anodes in an electrolysis cell~~

BACKGROUND OF THE INVENTION

1. Technical Field

_____ The present invention concerns a method for positioning when replacing
anodes in an electrolysis cell, and equipment for carrying out this method.

2. Description of the Related Art

_____ Electrolysis cells of the Hall-Héroult type with prebaked anodes for the
production of aluminium require regular replacement of used anodes with new ones
during operation. Such prebaked anodes comprise a prebaked or calcined carbon
block to which an anode suspender is attached via nipples that are fastened to the
carbon block. The anode suspender and its nipples are of a metallic material. The
combination of carbon block and anode suspender are usually called the anode,
and this is fastened via the anode suspender to the superstructure of the electrolysis
cell, more precisely to an anode beam that may run in the longitudinal direction of the
cell. A standard cell design comprises two anode beams, and a certain number of
anodes may be arranged side by side along each of the beams. Often each anode
beam may have 8-10 anodes. The carbon material in the anodes is consumed
during the electrolysis process and must be replaced before the metallic material in
the nipples is revealed. This process takes approximately 28 days and, in an
electrolysis hall with several tens of cells, there will be an extensive need for the
removal of used anodes and the insertion of new ones. In this operation, it is
important for the lower side of the new anode that is inserted to be positioned as
correctly as possible in the position of the used anode in terms of height. This is
because the interpolar distance (the distance between the anode and the cathode) is
an important parameter in the cell.

_____ Today this operation is increasingly performed using a traversing crane
mounted on rails that runs along the rows of electrolysis cells and is usually

positioned above them. The operation stated is one of the more labor-
intensive~~labour-intensive~~ and frequent operations during the operation of electrolysis
cells, and the various players within the industry have developed improvements to
simplify and rationalize~~rationalise~~ this work while focusing on the safety and working
5 | environment of the operators. An established method of determining the insertion
height of the new anode is to place it on a table beside the anode removed and to
mark a common reference level on the anode suspender with chalk. A measuring
stand is used as an auxiliary tool for this operation.

- 10 | US patent no. 4,221,641 concerns a method and an arrangement for replacing
electrodes in a reduction cell for the production of aluminium. The method involves
the transport path of a used anode from the cell to a first level above the cell being
registered so that the length of the electrode is measured, a new electrode being
lowered, whereby the distance from a second level parallel to the first level is
15 | detected to measure the length of the new electrode, measurement of the distance
between the levels stated and the new electrode being lowered further from the
second level for a distance that is equal to the transport path of the used anode
minus the distance between the two levels stated. To determine the level, this
solution comprises an arm which is activated by the electrodes and which also has a
20 | detector to detect the arm's motion. The detector consists of a beam of light and a
receiver, and the beam of light is broken by a screen mounted on the arm. The
detector solution is of the optical/mechanical type with moving parts that easily can
move out of position over time and/or require extensive maintenance/inspection to
ensure the mobility and correct function of the components. This principle of
25 | measurement is based upon the use of an incremental counter in addition to limit
switches, where the relative movement of the crane is counted.

- _____ The present invention represents a method and equipment for the
replacement of anodes in an electrolysis plant that provide very precise positioning of
30 | the anodes and are more robust in the face of dust, wear and mechanical stress than
prior art solutions. Moreover, the solution requires little inspection and has a good
user interface for the operator who operates the crane.

~~These and further advantages may be achieved with the invention in accordance with the attached claims 1-10.~~

BRIEF DESCRIPTION OF THE DRAWINGS

____ The present invention will be described in further detail in the following by
5 means of figures and examples, where:

Figs. 1 a-b show elementary diagrams with vital parts of the measuring equipment,
with and without an anode; and

10 Fig. 2 shows an elementary diagram of how the measurements are performed.

DETAILED DESCRIPTION OF THE INVENTION

____ As stated above, one intention of the present method is to achieve more
15 precise insertion of anodes by means of more precise distance measurement using improved equipment involving distance measurement using a laser. This avoids random anode hoist measuring errors, and there is less possibility of incorrect operation thanks to the interlocking technology chosen. The measuring principle and the sequence used eliminate measuring errors in connection with the vertical
20 deflection of the crane bridge and random play in the coarse structure.

____ Compared with manual measurement with a measuring stand and reference level, replacing anodes is less labor-intensive~~labour-intensive~~ with this method – no operator is required on the floor for insertion and for positioning of the anode height,
25 and the anode insertion height is more precise, which is important for the operation of the cell.

____ With reference to Figure 1a, the measuring equipment comprises a laser cell 3 installed inside a tight cabinet 4 with a vertical protection tube 5. The laser beam 7
30 shines through the tube towards a reflective tag 6 placed on the anode gripper 2.

Under these circumstances, the laser cell will measure the precise distance. The tight cabinet, together with the protection tube and air overpressure that is supplied to the cabinet 4 via an air supply pipe 8, prevent fluoride dust and gas from reaching the

cell's lens. This combination will produce precise measurement without random measuring errors. Cables for communication with the PLC run from the cabinet.

5 A lifting device, the anode hoist, is mounted on a rotation crab on the combination crane that is able to lift a burned-out anode out of an electrolysis cell and replace it with a new anode. The anode hoist is hydraulically controlled, i.e. the anode and anode suspender are lifted out of and lowered into the cell by means of hydraulic force.

10 The anode hoist is equipped with an anode gripper. This is a gripping device that is fastened to the anode hoist. It can grip the anode suspender 10 that is fastened to the anode 11 (see Fig. 1b). Conventionally, the anode suspender has a hole in its upper part that can be gripped by a gripping device. Such gripping devices may comprise one or more studs that can be entered into the hole in the suspender.

15 The PLC means Programmable Logic Control. The PLC can control output signals (O) by means of input signals (I) and a logically constructed program. The PLC consists of several microprocessors. The PLC processor is located on the crane structure while several ~~decentralized~~decentralised I/O racks are located on the
20 mobile crabs and on the driver's cab. The ~~decentralized~~decentralised I/O racks are linked to the PLC processor by means of high-speed data communication, which is very noise immune. This avoids having many signal cables, which may be vulnerable to noise and error signals.

25 In this connection, laser measuring equipment can measure the distance between the laser cell and a reflective tag. The precision of this combination is approximately 1 mm. The laser cell used in the example has RS-232 communication with the ~~decentralized~~decentralised racks. The laser cell is expediently located inside a tight cabinet with overpressure attached to a flanged protection tube, for
30 example of diameter 50 mm and length approximately 2.5 m. The laser beam is designed so that it shines from the cabinet through the tube and down towards the reflective tag on the anode gripper.

_____RS-232 (ASCII characters – port to port) communication is a data communication method that precisely transfers signals from the laser cell to the PLC.

5 _____A PanelView (not shown) is a screen-based visualization~~visualisation~~ system that communicates with the PLC via the same communication method as for decentralized~~decentralised~~ I/O racks. This visualization~~visualisation~~ system can read off all values saved as described below so that the crane driver in the cabin~~cab~~ can read the values.

10 _____A light panel (not shown) comprises a column of light with 5 lights of different color~~couleurs~~. This light panel has 2 function modes. Mode 1 is used when removing the anode and indicates the measuring sequences step by step. Mode 2 is positioning indication when inserting the anode. This indicates when the anode is too high, too low or in the correct position. This is based on an algorithm that is
15 programmed in the PLC.

1) PLC Interlocking (PLC interlocking in the PLC-program)

The sequence is interlocked so that mechanical play is always eliminated. This is done by the operator having to use the joystick for the anode hoist UP
20 STAGE 1 for a minimum of 2 seconds and to use the REMEMBER MEASURED VALUE switch at the same time before the anode gripper position is saved in the PLC.
When the joystick for the anode hoist is in the position UP STAGE 1, the hydraulic aggregate ensures, with the appropriate valves, that the anode hoist
25 has approximately 60-70% lifting force in relation to the weight of a burned-out anode.

2) Integrated PLC Solution

The PLC installation results in the signal transfer between the laser cell and
30 the PLC being very noise immune, the signal transfer being reliable and random error measurements not being produced.

3) Visualization~~Visualisation~~

Simple visualization~~visualisation~~ shows the sequence and produces reliable positioning of the new anode.

_____The crane in the example is controlled by the PLC with intelligent
5 decentralized~~decentralised~~ I/O racks. The distance laser measuring equipment
communicates with the decentralized~~decentralised~~ I/O racks. The laser cell and one
decentralized~~decentralised~~ rack must be positioned on the anode hoist as the laser
cell transfers measured values to the PLC processor via an intelligent
10 decentralized~~decentralised~~ I/O rack. It is important for the transfer of values between
the laser cell and the PLC to be as noise immune as possible in relation to
electromagnetic and electrostatic beams and not to be affected by temperature
fluctuations in order to avoid error signals. This is achieved with the PLC structure
chosen.

15 _____The laser measuring equipment with the laser cell is, as stated above, located
inside a dust-tight cabinet 4 (the electrotechnical designation is IP 56) on the rotating
anode hoist crab. The cabinet has a flanged tube 5 of diameter 50 mm and length
approximately 2.5 m mounted on it, which extends down towards the reflective tag 6.
The reflective tag is fastened to the anode gripper 2. The laser measuring equipment
20 measures the distance between a fixed point in this tight cabinet (the installation
location) on the anode hoist through the tube and down towards the reflective tag on
the anode gripper. The tight cabinet is provided with overpressure and a long tube
as stated so that the powerful upward air flows (hot air with a lot of gas containing
fluorine and dust in connection with anode replacement) do not reach the lens of the
25 laser cell. This is an important detail in the prevention of error measurements. The
laser measuring principle described is a central part of the present invention as it is
not subject to mechanical wear and does not require maintenance.

30 _____A PanelView 550 visualization~~visualisation~~ panel is installed inside the crane
cab so that all measurements and stages in the sequence can be read off. This is
controlled by the PLC.

_____A function light panel is installed in front of the operator with 5 indicator lamps.
This function display has 2 modes. This is made for the operator to let him monitor

the functions in connection with the insertion of anodes, in particular the mounting height for the new anode (for more information, see the functional description).

5 | _____ The operator's controls comprise a joystick on the left side, which has 3 stages for upward movement of the anode gripper.

10 | UP STAGE 1 exerts a lifting force on the anode gripper of approximately 60-70% of the weight of the burned-out anode and has a relatively low lifting speed. This force setting is used when the anode gripper height needs to be measured using the laser equipment.

15 | UP STAGE 2 exerts a lifting force on the anode gripper of approximately 300% of the weight of the burned-out anode (breakaway force when removing an anode) and has the same speed as UP STAGE 1.

UP STAGE 3 exerts a lifting force on the anode gripper of approximately 200% of the weight of the burned-out anode and has a high speed for rapid anode handling. On the same joystick as stated above, there is a press-button switch at the front. This is used to operate REMEMBER ANODE GRIPPER POSITION.

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Functional Description, see Figure 2

25 | All the functions described are carried out by the operator in the crane cab. The operator first sets the offset value on the PanelView, i.e. how much higher the new anode is to be inserted in relation to the burned-out anode (the typical setting is 20 mm). The operator guides the crane so that he grips the anode suspender (the anode) with the anode gripper. He then lifts the burned-out anode by operating the anode hoist UP STAGE 1 with the joystick (see Figure 2a). This involves the anode hoist lifting with a preset force that is approximately 60-70% of the anode weight
30 | (constant force). This results in the elimination of play. While the lifting is taking place, the operator presses the REMEMBER POSITION switch on the joystick. The anode gripper position is saved in the PLC if UP STAGE 1 lifting has been active continuously for 2 seconds. If the operator uses UP STAGE 2, the anode gripper position will not be saved in the PLC. This is an important interlocking function in the

PLC to eliminate play and to ensure that the crane is deflected in approximately the same way for all measurements. When this has been done in accordance with the method, the PLC will acknowledge this with a yellow light on the light panel. This means that measurement A has been completed. The anode clip is loosened and the burned-out anode is removed from the cell.

_____ The burned-out anode is placed down on the reference level (checker plate), see Figure 2b. The anode is lifted up by using anode hoist UP STAGE 1, i.e. the anode hoist will again lift with approximately 60-70% of the anode weight. The burned-out anode will not be lifted from the reference level, but the crane structure is extended in the same way as when lifting the anode out of the cell. This results in the play in the crane being eliminated. While the lifting is taking place, the operator presses the REMEMBER POSITION switch on the joystick. The position is saved in the PLC if the UP STAGE 1 lifting was active for 2 seconds. When this has been done correctly, the PLC will acknowledge this with a green light on the light panel. This means that measurement B has been completed.

_____ The old anode is then placed in a waste bin. The new anode is fastened to the anode gripper. This is then placed on the same reference level as for the burned-out anode, see Figure 2c. The anode is lifted up by using UP STAGE 1, i.e. the anode hoist will again lift with approximately 60-70% of the anode weight. While the lifting is taking place, the operator presses the REMEMBER POSITION switch on the joystick. The position is saved in the PLC if the UP STAGE 1 lifting was active for 2 seconds. When this has been done correctly, the PLC will acknowledge this with a red light on the light panel. This means that measurement C has been completed. All the measurements have now been completed.

_____ The PLC calculates the insertion height of the new anode using this formula – see Figure 2d:

30 $D=A-B+C-X$

D is the desired position of the new anode.

A is the position of the burned-out anode in the cell.

B is the position of the burned-out anode on the reference level.

C is the position of the new anode on the same reference level.

X is the additional height of the new anode in the cell in relation to the burned-out anode.

5 | ____ The new anode is inserted in the cell at anode position = D (+/- tolerance, typically +/- 3 mm - the tolerance can be adjusted from the operator panel).

10 | The indicator panel then switches to Mode 2 for indication. The operator inserts the anode in the cell in accordance with the light indication in Mode 2, i.e. if the yellow lights light up (1 or 2 yellow lights), the anode is too high, and if the red lights light up (1 or 2 red lights), the anode is too low. The anode has the correct height position if the green light lights up, i.e. the anode is in position D +/- 3 mm. When the anode is positioned in the cell and the green light lights up, the anode is fixed with the anode clamp. The sequence has been completed, and the equipment can be used to replace an anode in another cell.

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____ Additional insertion height for a new anode is important to avoid anode deformation. The additional height means that the anode does not draw "full power", and it is allowed to heat up gradually before full current flows through it.

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ABSTRACT~~Abstract~~

5 | ~~_____The present invention concerns a~~A method and equipment for replacing
anodes in an electrolysis cell in which a crane with an anode gripper is used to lift out
used anodes and to insert new anodes. The new anode is inserted at a height in
accordance with a calculated height based on the height of the anode removed, the
height of the anode removed and the height of the new anode being measured
10 | against a common reference level. Laser-based measuring equipment is arranged
between a point on the crane, which is stationary in terms of height during the
operation, and a point on the anode gripper, which moves together with the anode,
and measures the heights stated. The measured values are processed by a PLC-
based system, which determines a more precise insertion height of the new anode in
15 | accordance with a specific algorithm.

(~~Figure 1 and Figure 2 are published with the abstract~~)